86-4195

# Technique For Estimating Depths Of 100-Year Floods In Pennsylvania

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 86-4195

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# TECHNIQUE FOR ESTIMATING DEPTHS OF 100-YEAR FLOODS IN PENNSYLVANIA

By Herbert N. Flippo, Jr.

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 86-4195

Harrisburg, Pennsylvania

1990

U.S. DEPARTMENT OF THE INTERIOR

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## CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who prefer metric (International System) units rather than the inch-pound used in this report, the following conversion factors may be used:

| Multiply inch-pound unit | By | To obtain metric unit |
|---|---|---|
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |
| cubic foot per second per square mile $(ft^3/s)/mi^2$ | 0.01093 | cubic meter per second per square kilometer $(m^3/s)/km^2$ |
| foot (ft) | 0.3048 | meter (m) |
| foot per second (ft/s) | 0.3048 | meter per second (m/s) |
| inch (in.) | 25.40 | millimeter (mm) |
| mile (mi) | 1.609 | kilometer (km) |
| square foot ($ft^2$) | 0.0929 | square meter ($m^2$) |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |

# TECHNIQUE FOR ESTIMATING DEPTHS OF 100-YEAR FLOODS IN PENNSYLVANIA

By Herbert N. Flippo, Jr.

## ABSTRACT

Techniques are developed for estimating 100-year flood depths in natural channels of unregulated Pennsylvania streams that drain less than 2,200 square miles. Equations and graphs are presented relating the depth of the 100-year flood above median stage to drainage area in five defined hydrologic areas in the State. Another graph defines the relation between drainage area and median depth of flow over the low point of riffles. Thus, 100-year depths on riffles can be estimated by summing depth values derived from two simple relations.

## INTRODUCTION

Maps showing areas of potential flood hazards are useful tools in flood-plain management. Preparations of such maps usually entails the estimation of flood depths, for a chosen recurrence interval, along stream channels or other paths of flow. Most commonly, flood profiles that correspond to 100-year flood depths along principal stream channels are developed to define, for mapping purposes, the spatial distribution of high-water elevations. The resultant map of 100-year flood boundaries delineates those areas having a probability of about 1 in 100 of being flooded in any year.

### Purpose and Scope

The purpose of this report is to present a method, using simple relations, to estimate 100-year depths of floods in natural channels of unregulated streams in Pennsylvania.

The depth of the 100-year flood above median stage--the stage corresponding to median (50th percentile) flow--can easily be estimated for unregulated streams throughout Pennsylvania. Mathematical relations, in which drainage area is the only independent variable, are provided for making such estimates for streams in five hydrologic areas. The range of application in three areas is from 1 to 2,200 $mi^2$ (square miles). The lower limit of applicability in the other two areas is also 1 $mi^2$; however, the upper limits are 325 and 560 $mi^2$, which approximates the areas of the largest drainage basins therein. A graph is provided for estimating median depth.

## TECHNIQUE FOR ESTIMATING 100-YEAR FLOOD DEPTHS

### Method of Analysis

The relation of flood depth to flood discharge, as developed by Leopold and Maddock (1953), is of the form:

$$d = cQ^f, \quad (1)$$

where d is the average cross-sectional depth, Q is the discharge for a given probability of occurrence, and c and f are constants. Flippo (1977 and 1982) has shown that for probabilities of occurrence in the range of 0.5 to 0.01 for an annual event--corresponding to recurrence intervals of 2 to 100 years--there is a high correlation between unregulated flood discharges and drainage area for most streams in Pennsylvania. Consequently, for this study the equation of Leopold and Maddock was revised to a depth-predictive equation for unregulated streams of the form:

$$D_{100} = cA^f, \quad (2)$$

in which: A is the area of the drainage basin, $D_{100}$ is the depth of the 100-year flood above the stage of median flow, and c and f are constants for the 100-year flood.

Relations between flood depth and drainage area were developed in this study using graphical methods. Data on the depths, in feet, of 100-year floods above median stream stages were regressed against drainage areas (A, in square miles) for 281 gaging stations on essentially unregulated streams. Regionalization procedures (Riggs, 1973) were used to minimize regression errors for five hydrologic areas (A-E), which are delineated on the map of plate 1. Gaging stations for which the stage-discharge relations are affected by channelization, or by backwater from bridges or other hydraulic controls, were omitted from this analysis. The drainage basins for several gaging stations lie in more than one hydrologic area. Each of these stations was grouped with those stations that served to define the hydrologic area in which the gage lies. Locations of the gaging stations are shown in plate 1.

Results of the regressions are summarized in table 1 and figure 1. Data on drainage area, stages for median flow and the 100-year flood, and the depth of the 100-year flood above median stage are given in table 2. Owing to uncertainties in the definition of median-flow and 100-year-flood stages, computed depths of 100-year floods above median stages are less accurate than the hundredths-of-a-foot precision shown in this table.

Median stream stages (table 2) are those gage heights that correspond to median flows at the respective gaging stations. Median flows for continuous-record stations were determined by magnitude-frequency analyses of daily mean discharges. Median flows at crest-stage partial-record stations were estimated from median-flow/drainage-area ratios for nearby continuous-record stations. Stage-discharge relations were used to translate the median flows into corresponding stream stages.

Table 1.--Summary of equations for estimating 100-year flood depth

[ft, feet; mi², square miles]

| Hydrologic area | Equation | [1]N | Areal means $D_{100}$ (ft) | Areal means [2]A ($mi^2$) | Applicable range in [2]A ($mi^2$) | Standard error (percent) |
|---|---|---|---|---|---|---|
| A | [3] $D_{100} = 1.80\ A^{.380}$ | 15 | 7.19 | 38.2 | 1 - 325 | 24 |
| B | $D_{100} = 6.50\ A^{.167}$ | 55 | 12.21 | 43.5 | 1 - 2,200 | 22 |
| C | $D_{100} = 3.72\ A^{.241}$ | 155 | 9.80 | 55.7 | 1 - 2,200 | 25 |
| D | $D_{100} = 2.31\ A^{.252}$ | 27 | 6.52 | 61.5 | 1 - 2,200 | 16 |
| E | $D_{100} = 2.87\ A^{.261}$ | 29 | 7.52 | 40.0 | 1 - 560 | 28 |

[1] Number of gaging stations for which depth and drainage-area values were used in regression analysis. The arithmetic averages of these N values are the "areal means".

[2] A = Drainage area above site, in square miles.

[3] $D_{100}$ = Depth of 100-year flood above median stage, in feet.

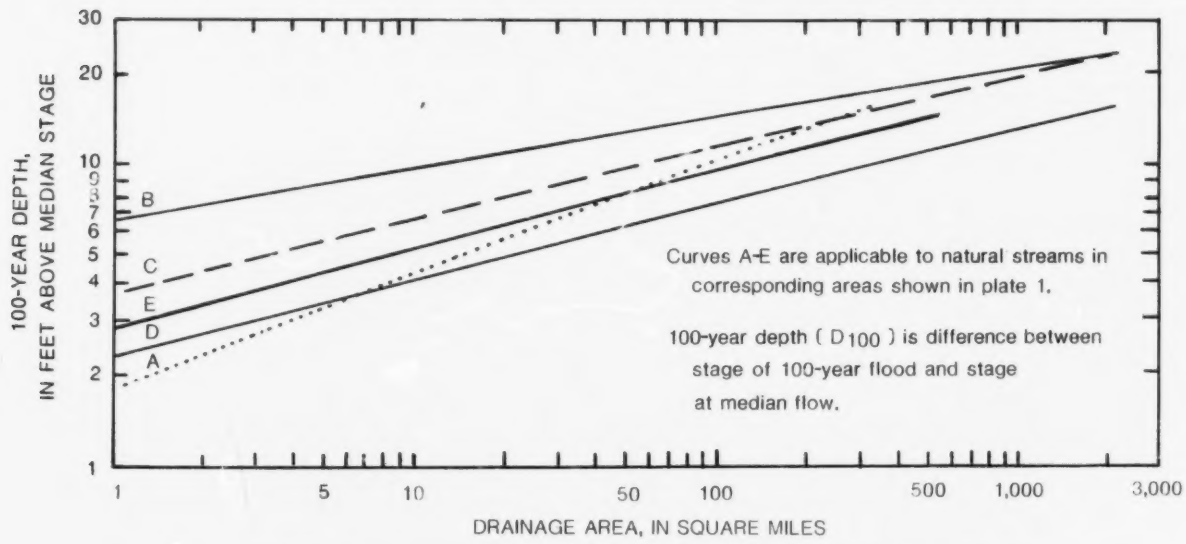


Figure 1.--Relation between 100-year flood depth and drainage area in five hydrologic areas.

Stages for 100-year floods are those gage heights that correspond to 100-year instantaneous peak discharges. Station estimates of 100-year-flood discharges were computed through use of procedures set forth by the U.S. Water Resources Council, as revised by the Hydrology Subcommittee, Interagency Advisory Committee on Water Data (1982). Final estimates of 100-year-flood discharges were developed by weighting each station estimate with a regional estimate, as computed from a regional regression equation developed by Flippo (1982, table 3). The weighting procedure (Flippo, 1977, Appendix D) weights the two 100-year estimates in proportion to the number of annual peaks used to compute the station estimate and the equivalent years of record for the applicable regional regression equation.

Gaging stations for which there are fewer than 10 unregulated annual peak discharges of record, or for which the stage-discharge relation is not representative of natural hydraulic control in the channel, or for which the drainage area exceeds 2,200 $mi^2$, were not considered in this depth analysis.

A graph of drainage area versus median depth was prepared to facilitate the estimation of total 100-year depth. This graph (fig. 2) resulted from the least-squares fitting of median-depth values for 151 of the 281 gaging stations listed in table 2. Median-depth values were determined by subtracting the measured stage at the low point of the riffle that forms the low-water hydraulic control at the gaging station ("point of zero flow") from the stage at median flow (table 2). Only those measurements of riffle low points that were consistent with the stage-discharge relations used in the preparation of table 2 were considered. No reliable riffle measurements were available for many gage sites, including most partial-record stations. Riffle measurements for many other sites were unsuitable for this analysis, because the low-water controls are artificial structures.

Table 2.--Summary of gaging-station data

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow Stage (ft) | Median flow Discharge ($ft^3/s$) | 100-year flood Stage (ft) | 100-year flood Discharge ($ft^3/s$) | Depth of 100 year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA A | | | | | | | | |
| 01431680 | Mill Brook near Paupack | 41 23 | 75 14 | 4.84 | 3.92 | 2.6 | 6.75 | 616 | 2.83 |
| 01432500 | Shohola Creek near Shohola | 41 27 | 74 55 | 83.6 | 2.05 | 120 | 8.25 | 6,000 | 6.20 |
| 01438300 | Vandermark Creek at Milford | 41 20 | 74 48 | 5.36 | 1.52 | 2.8 | 4.20 | 668 | 2.68 |
| 0143950U | Bush Kill at Shoemakers | 41 05 | 75 02 | 117 | 1.75 | 160 | 10.05 | 10,800 | 8.30 |
| 01440300 | Mill Creek at Mountainhome | 41 10 | 75 16 | 5.84 | 3.01 | 3.6 | 7.65 | 2,380 | 4.64 |
| 01440400 | Brodhead Creek near Analomink | 41 05 | 75 13 | 65.9 | 1.94 | 75 | 11.90 | 13,200 | 9.96 |
| 01441000 | McMichaels Creek at Stroudsburg | 40 59 | 75 12 | 65.3 | 2.55 | 81 | 11.30 | 7,440 | 8.75 |
| 01442500 | Brodhead Creek at Minisink Hills | 40 60 | 75 09 | 259 | 2.89 | 320 | 17.85 | 45,100 | 14.96 |
| 01446600 | Martins Creek near East Bangor | 40 54 | 75 12 | 10.4 | 1.70 | 6.2 | 5.10 | 3,040 | 3.40 |
| 01447500 | Lehigh River at Stoddartsville | 41 08 | 75 38 | 91.7 | .96 | 120 | 13.58 | 19,500 | 12.62 |
| 01447720 | Tobyhanna Creek near Blakeslee | 41 05 | 75 36 | 118 | 2.68 | 160 | 15.80 | 14,800 | 13.12 |
| 01448000 | Lehigh River at Tannery | 41 02 | 75 46 | 322 | 2.00 | 440 | 19.20 | 41,200 | 17.20 |
| 01448500 | Dilldown Creek near Long Pond | 41 02 | 75 33 | 2.39 | 1.24 | 3.1 | 4.37 | 851 | 3.13 |
| 01449360 | Pohopoco Creek at Kresgeville | 40 54 | 75 30 | 49.9 | 3.36 | 70 | 14.20 | 6,460 | 10.84 |
| 01450500 | Aquashicola Creek at Palmerton | 40 48 | 75 36 | 76.7 | 3.53 | 98 | 12.80 | 9,920 | 9.27 |
| | AREA B | | | | | | | | |
| 01427650 | North Branch Calkins Creek near Damascus | 41 42 | 75 10 | 7.02 | 2.25 | 3.7 | 9.15 | 1,530 | 6.90 |
| 01428500 | Delaware River near Barryville, NY | 41 31 | 74 59 | 2,020 | 3.17 | 1,800 | 26.40 | 130,000 | 23.23 |
| 01429000 | West Branch Lackawaxen River at Prompton | 41 35 | 75 20 | 59.7 | 1.53 | 63 | 12.40 | 10,200 | 10.87 |
| 01429500 | Dyberry Creek near Honesdale | 41 38 | 75 16 | 64.6 | 1.73 | 50 | 16.70 | 16,100 | 14.97 |
| 01430000 | Lackawaxen River near Honesdale | 41 34 | 75 15 | 164 | 1.10 | 160 | 20.60 | 28,000 | 19.50 |
| 01430500 | Lackawaxen River at West Hawley | 41 28 | 75 11 | 206 | 1.78 | 200 | 20.10 | 31,600 | 18.32 |
| 01431000 | Middle Creek near Hawley | 41 29 | 75 13 | 78.4 | .75 | 63 | 18.10 | 12,500 | 17.35 |
| 01431500 | Lackawaxen River at Hawley | 41 28 | 75 10 | 290 | 2.28 | 240 | 21.97 | 42,500 | 19.69 |
| 01451000 | Lehigh River at Walnutport | 40 45 | 75 36 | 889 | 2.81 | 1,400 | 19.70 | 90,390 | 16.89 |
| 01451800 | Jordan Creek near Schnecksville | 40 40 | 75 38 | 53.0 | 2.93 | 45 | 14.20 | 9,480 | 11.27 |
| 01453000 | Lehigh River at Bethlehem | 40 37 | 75 23 | 1,279 | 2.15 | 1,600 | 30.20 | 110,300 | 28.05 |
| 01458900 | Tinicum Creek near Ottsville | 40 28 | 75 08 | 14.7 | 1.07 | 5.7 | 9.80 | 10,230 | 8.73 |
| 01459500 | Tohickon Creek near Pipersville | 40 26 | 75 07 | 97.4 | 1.32 | 37 | 12.50 | 21,200 | 11.18 |
| 01465500 | Neshaminy Creek near Langhorne | 40 10 | 74 57 | 210 | 1.18 | 120 | 21.52 | 42,300 | 20.34 |
| 01465770 | Poquessing Creek at Trevose Road, Philadelphia | 40 08 | 75 00 | 5.08 | 1.50 | 3.5 | 9.20 | 2,900 | 7.70 |
| 01465780 | Poquessing Creek above Byberry Cr, Philadelphia | 40 04 | 74 59 | 13.2 | 1.71 | 6.3 | 12.70 | 5,830 | 10.99 |
| 01465785 | Walton Run at Philadelphia | 40 05 | 75 00 | 2.17 | 2.41 | 1.2 | 11.40 | 1,850 | 8.99 |
| 01465790 | Byberry Creek at Chalfont Road, Philadelphia | 40 05 | 74 59 | 5.34 | 1.89 | 3.4 | 13.30 | 2,960 | 11.41 |
| 01465795 | Byberry Creek at Grant Avenue, Philadelphia | 40 04 | 75 00 | 7.13 | 2.40 | 3.7 | 13.70 | 4,760 | 11.30 |
| 01465798 | Poquessing Creek at Grant Ave., Philadelphia | 40 03 | 74 59 | 21.4 | 2.92 | 11 | 15.25 | 10,500 | 12.33 |
| 01467042 | Pennypack Creek at Pine Road, Philadelphia | 40 05 | 75 04 | 37.9 | 3.10 | 34 | 12.48 | 7,590 | 9.38 |
| 01467043 | Stream 'A' at Philadelphia | 40 05 | 75 04 | 1.20 | 9.75 | .67 | 16.00 | 1,200 | 6.25 |
| 01467045 | Pennypack Creek below Veree Road, Philadelphia | 40 05 | 75 03 | 42.8 | 3.98 | 35 | 15.20 | 8,960 | 11.22 |
| 01467048 | Pennypack Creek at Rhawn Street, Philadelphia | 40 03 | 75 02 | 49.8 | 2.39 | 40 | 13.00 | 11,400 | 10.61 |
| 01467050 | Wooden Bridge Run at Philadelphia | 40 03 | 75 01 | 3.35 | 3.22 | 1.6 | 13.45 | 2,960 | 10.23 |
| 01467086 | Tacony Creek at County Line, Philadelphia | 40 03 | 75 07 | 16.6 | 2.27 | 14 | 13.50 | 6,920 | 11.23 |
| 01467089 | Frankford Creek at Torresdale Ave., Philadelphia | 40 00 | 75 06 | 33.8 | 3.71 | 23 | 15.55 | 11,600 | 11.84 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow: Stage (ft) | Median flow: Discharge ($ft^3/s$) | 100-year flood: Stage (ft) | 100-year flood: Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | | AREA B--Continued | | | | | | | |
| 01467500 | Schuylkill River at Pottsville | 40 41 | 76 11 | 53.4 | 2.73 | 65.0 | 14.50 | 9,470 | 11.77 |
| 01468500 | Schuylkill River at Landingville | 40 38 | 76 08 | 133 | 3.21 | 180 | 19.80 | 17,900 | 16.59 |
| 01469500 | Little Schuylkill River at Tamaqua | 40 48 | 75 58 | 42.9 | 2.29 | 49 | 10.99 | 7,520 | 8.70 |
| 01470500 | Schuylkill River at Berne | 40 31 | 75 60 | 355 | 5.23 | 430 | 18.82 | 42,000 | 13.59 |
| 01471000 | Tulpehocken Creek near Reading | 40 22 | 75 59 | 211 | 1.57 | 200 | 17.10 | 19,600 | 15.53 |
| 01471510 | Schuylkill River at Reading | 40 20 | 75 56 | 880 | 3.13 | 940 | 28.60 | 71,000 | 25.47 |
| 01471980 | Manatawny Creek near Pottstown | 40 16 | 75 41 | 85.5 | 2.12 | 59 | 13.60 | 10,400 | 11.48 |
| 01472000 | Schuylkill River at Pottstown | 40 14 | 75 39 | 1,147 | 2.22 | 1,200 | 28.00 | 88,000 | 25.78 |
| 01472157 | French Creek near Phoenixville | 40 09 | 75 36 | 59.1 | 4.58 | 54 | 15.50 | 16,100 | 10.92 |
| 01473000 | Perkiomen Creek at Graterford | 40 14 | 75 27 | 279 | 1.47 | 160 | 20.30 | 48,600 | 18.83 |
| 01473100 | Zacharias Creek near Skippack | 40 12 | 75 22 | 7.27 | 4.45 | 7.4 | 10.80 | 10,200 | 6.35 |
| 01473120 | Skippack Creek near Collegeville | 40 10 | 75 26 | 53.7 | 1.55 | 28 | 18.30 | 21,400 | 16.75 |
| 01473900 | Wissahickon Creek at Fort Washington | 40 07 | 75 13 | 40.8 | 1.90 | 24 | 17.60 | 7,150 | 15.70 |
| 01473950 | Wissahickon Creek at Bells Mill Rd., Philadelphia | 40 05 | 75 14 | 53.6 | 3.34 | 37 | 13.70 | 9,720 | 10.36 |
| 01473980 | Wissahickon Creek at Livezey Lane, Philadelphia | 40 03 | 75 13 | 59.2 | 1.53 | 41 | 8.60 | 10,500 | 7.07 |
| 01474000 | Wissahickon Creek at mouth, Philadelphia | 40 01 | 75 12 | 64.0 | 2.23 | 44 | 10.85 | 11,200 | 8.62 |
| 01475300 | Darby Creek at Waterloo Mills near Devon | 40 01 | 75 25 | 5.15 | 1.54 | 5.2 | 8.70 | 3,340 | 7.16 |
| 01475510 | Darby Creek near Darby | 39 56 | 75 16 | 37.4 | 1.53 | 47 | 11.74 | 8,860 | 10.21 |
| 01475530 | Cobbs Creek at U.S. Highway 1, Philadelphia | 39 59 | 75 17 | 4.78 | 2.29 | 3.7 | 12.20 | 5,490 | 9.91 |
| 01475550 | Cobbs Creek at Darby | 39 55 | 75 15 | 22.0 | 1.46 | 9.0 | 11.50 | 7,400 | 10.04 |
| 01476000 | Crum Creek at Woodlyn | 39 53 | 75 21 | 33.3 | 2.31 | 18 | 11.22 | 5,150 | 8.91 |
| 01476030 | Little Crum Creek at Michigan Ave., Swarthmore | 39 54 | 75 20 | 1.15 | 2.30 | .85 | 10.80 | 1,160 | 8.50 |
| 01476500 | Ridley Creek at Moylan | 39 54 | 75 24 | 31.9 | 1.43 | 31 | 13.10 | 7,920 | 11.67 |
| 01477000 | Chester Creek near Chester | 39 52 | 75 25 | 61.1 | 2.86 | 55 | 22.90 | 18,200 | 20.04 |
| 01478200 | Middle Branch White Clay Creek near Landenberg | 39 47 | 75 48 | 12.7 | 3.41 | 8.85 | 15.50 | 6,340 | 12.09 |
| 01480610 | Sucker Run near Coatesville | 39 58 | 75 51 | 2.57 | 2.00 | 2.2 | 10.90 | 2,660 | 8.90 |
| 01480617 | West Branch Brandywine Creek at Modena | 39 58 | 75 48 | 55.0 | 3.08 | 56 | 16.10 | 14,600 | 13.02 |
| 01481000 | Brandywine Creek at Chadds Ford | 39 52 | 75 36 | 287 | 1.79 | 270 | 17.00 | 26,100 | 15.21 |
| | | AREA C | | | | | | | |
| 01516500 | Corey Creek near Mainsburg | 41 47 | 77 01 | 12.2 | 1.68 | 3.4 | 9.69 | 4,370 | 8.01 |
| 01516800 | Manns Creek near Mansfield | 41 49 | 77 06 | 3.01 | 2.92 | .85 | 10.00 | 1,130 | 7.08 |
| 01517000 | Elk Run near Mainsburg | 41 49 | 76 58 | 10.2 | .51 | 2.9 | 5.67 | 3,470 | 5.16 |
| 01518000 | Tioga River at Tioga | 41 54 | 77 08 | 282 | 1.61 | 120 | 19.28 | 51,680 | 17.67 |
| 01518500 | Crooked Creek at Tioga | 41 54 | 77 09 | 122 | 2.61 | 31 | 17.40 | 20,250 | 14.79 |
| 01520000 | Cowanesque River near Lawrenceville | 41 59 | 77 09 | 298 | 7.22 | 78 | 18.50 | 48,200 | 11.28 |
| 01531250 | North Branch Sugar Creek tributary near Columbia Cross Roads | 41 50 | 76 50 | 8.83 | 1.69 | 2.5 | 6.82 | 3,320 | 5.13 |
| 01532000 | Towanda Creek near Monroeton | 41 42 | 76 28 | 215 | 7.03 | 110 | 18.90 | 52,500 | 11.87 |
| 01532200 | South Branch Towanda Creek at New Albany | 41 35 | 76 26 | 13.3 | 2.67 | 9.0 | 11.10 | 3,770 | 8.43 |
| 01532850 | Middle Branch Wyalusing Creek tributary near Richardville | 41 52 | 76 00 | 5.67 | 3.96 | 3.7 | 7.80 | 2,180 | 3.84 |
| 01533250 | Tuscarora Creek near Silvara | 41 42 | 76 07 | 11.8 | 2.75 | 7.8 | 8.62 | 3,130 | 5.87 |
| 01533500 | North Branch Mehoopany Creek near Lovelton | 41 32 | 76 09 | 35.2 | 2.47 | 21 | 9.95 | 14,500 | 7.48 |
| 01533800 | Butler Creek at Gibson | 41 48 | 75 39 | 7.38 | 2.44 | 4.5 | 8.30 | 2,820 | 5.86 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow: Stage (ft) | Median flow: Discharge ($ft^3/s$) | 100-year flood: Stage (ft) | 100-year flood: Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA C--Continued | | | | | | | | |
| 01533950 | South Branch Tunkhannock Creek near Montdale | 41 34 | 75 39 | 12.6 | 1.25 | 5.7 | 7.30 | 3,290 | 6.05 |
| 01534000 | Tunkhannock Creek near Tunkhannock | 41 33 | 75 54 | 383 | 2.01 | 240 | 14.60 | 42,600 | 12.59 |
| 01537500 | Solomon Creek at Wilkes-Barre | 41 14 | 75 57 | 15.7 | 1.64 | 13 | 10.90 | 2,970 | 9.26 |
| 01538000 | Wapwallopen Creek near Wapwallopen | 41 04 | 76 06 | 43.8 | 1.56 | 40 | 10.64 | 4,970 | 9.08 |
| 01538800 | Huntington Creek near Pikes Creek | 41 19 | 76 09 | 4.94 | 4.78 | 3.3 | 11.40 | 2,070 | 6.62 |
| 01539000 | Fishing Creek near Bloomsburg | 41 05 | 76 26 | 274 | 2.44 | 250 | 15.60 | 34,000 | 13.16 |
| 01539500 | Little Fishing Creek at Eyers Grove | 41 05 | 76 31 | 56.5 | 1.75 | 37 | 10.30 | 6,720 | 8.55 |
| 01540000 | Fishing Creek at Bloomsburg | 41 00 | 76 28 | 355 | 3.35 | 400 | 20.00 | 35,700 | 16.65 |
| 01540200 | Trexler Run near Ringtown | 40 51 | 76 17 | 1.77 | 1.27 | .94 | 5.60 | 672 | 4.33 |
| 01541000 | West Branch Susquehanna River at Bower | 40 54 | 78 41 | 315 | 5.08 | 255 | 18.45 | 26,800 | 13.37 |
| 01541308 | Bradley Run near Ashville | 40 31 | 78 35 | 6.77 | 1.61 | 8.2 | 5.50 | 1,690 | 3.89 |
| 01541500 | Clearfield Creek at Dimeling | 40 58 | 78 24 | 371 | 3.60 | 280 | 18.80 | 26,450 | 15.20 |
| 01542000 | Moshannon Creek at Osceola Mills | 40 51 | 78 16 | 68.8 | .97 | 64 | 15.50 | 5,840 | 14.53 |
| 01542720 | Wilson Run at Penfield | 41 13 | 78 35 | 8.34 | 1.30 | 4.3 | 6.50 | 1,070 | 5.20 |
| 01543000 | Driftwood Br Sinnemahoning Creek at Sterling Run | 41 25 | 78 12 | 272 | 1.25 | 180 | 14.02 | 38,100 | 12.77 |
| 01543500 | Sinnemahoning Creek at Sinnemahoning | 41 19 | 78 05 | 685 | 2.63 | 470 | 25.08 | 74,400 | 22.45 |
| 01544450 | Germania Branch at Germania | 41 39 | 77 39 | 2.40 | .49 | 1.22 | 5.10 | 693 | 4.61 |
| 01544500 | Kettle Creek at Cross Fork | 41 29 | 77 50 | 136 | 2.01 | 96 | 15.00 | 20,200 | 12.99 |
| 01545600 | Young Womans Creek near Renovo | 41 23 | 77 41 | 46.2 | 1.88 | 33 | 9.30 | 7,230 | 7.42 |
| 01547800 | South Fork Beech Creek near Snow Shoe | 41 02 | 77 54 | 12.2 | 1.21 | 15.3 | 6.60 | 1,850 | 5.39 |
| 01547950 | Beech Creek at Monument | 41 07 | 77 42 | 152 | 6.00 | 170 | 18.00 | 13,500 | 12.00 |
| 01548020 | Bull Run near Loganton | 41 00 | 77 20 | 1.99 | 5.54 | 2.43 | 10.80 | 544 | 5.26 |
| 01548500 | Pine Creek at Cedar Run | 41 31 | 77 27 | 604 | 2.12 | 360 | 14.88 | 55,600 | 12.76 |
| 01549000 | Pine Creek near Waterville | 41 19 | 77 23 | 750 | 1.82 | 550 | 18.70 | 64,000 | 16.88 |
| 01549500 | Blockhouse Creek near English Center | 41 28 | 77 14 | 37.7 | 1.40 | 24 | 10.60 | 8,020 | 9.20 |
| 01549700 | Pine Creek below Little Pine Creek near Waterville | 41 16 | 77 19 | 944 | 2.37 | 510 | 20.92 | 92,600 | 18.55 |
| 01549780 | Larrys Creek at Cogan House | 41 25 | 77 10 | 6.80 | 1.11 | 4.0 | 6.63 | 1,860 | 5.52 |
| 01550000 | Lycoming Creek near Trout Run | 41 25 | 77 02 | 173 | 2.00 | 130 | 19.85 | 25,300 | 17.85 |
| 01551000 | Grafius Run at Williamsport | 41 15 | 77 01 | 3.14 | .77 | 1.5 | 4.10 | 1,460 | 3.33 |
| 01552000 | Loyalsock Creek at Loyalsockville | 41 20 | 76 54 | 443 | 3.83 | 370 | 14.36 | 81,600 | 10.53 |
| 01552100 | Mill Creek near Warrensville | 41 20 | 76 58 | 11.9 | .24 | 7.0 | 6.60 | 3,100 | 6.36 |
| 01552500 | Muncy Creek near Sonestown | 41 21 | 76 32 | 23.8 | 2.00 | 24 | 9.00 | 8,780 | 7.00 |
| 01553600 | East Branch Chillisquaque Creek near Washingtonville | 41 05 | 76 39 | 9.48 | 1.72 | 2.5 | 11.10 | 4,710 | 9.38 |
| 01555000 | Penns Creek at Penns Creek | 40 52 | 77 03 | 301 | 2.08 | 240 | 13.89 | 26,400 | 11.81 |
| 01555500 | East Mahantango Creek near Dalmatia | 40 37 | 76 55 | 162 | 1.99 | 110 | 19.50 | 24,600 | 17.51 |
| 01555800 | McDonald Run near East Freedom | 40 23 | 78 26 | 1.54 | 1.45 | 1.9 | 5.90 | 512 | 4.45 |
| 01556000 | Frankstown Branch Juniata River at Williamsburg | 40 28 | 78 12 | 291 | 2.95 | 190 | 22.90 | 24,500 | 19.95 |
| 01556400 | Sandy Run near Bellwood | 40 34 | 78 21 | 5.58 | 1.98 | 6.9 | 6.80 | 1,420 | 4.82 |
| 01556500 | Little Juniata River at Tipton | 40 38 | 78 18 | 93.7 | 2.05 | 82 | 12.00 | 10,500 | 9.95 |
| 01557100 | Schell Run at Tyrone | 40 40 | 78 15 | 1.68 | 1.24 | 2.1 | 4.64 | 570 | 3.40 |
| 01557500 | Bald Eagle Creek at Tyrone | 40 41 | 78 14 | 44.1 | .53 | 38 | 7.50 | 6,270 | 6.97 |
| 01558000 | Little Juniata River at Spruce Creek | 40 37 | 78 08 | 220 | 2.20 | 200 | 17.10 | 28,000 | 14.90 |
| 01559000 | Juniata River at Huntingdon | 40 29 | 78 01 | 816 | 1.79 | 590 | 20.23 | 58,000 | 18.44 |
| 01559500 | Standing Stone Creek near Huntingdon | 40 31 | 77 58 | 128 | 1.47 | 76 | 11.45 | 9,890 | 9.98 |
| 01559700 | Buffalo Run tributary near Manns Choice | 39 59 | 78 37 | 5.28 | .37 | 1.6 | 6.30 | 1,700 | 5.93 |
| 01560000 | Dunning Creek at Belden | 40 04 | 78 30 | 172 | 1.75 | 89 | 14.05 | 19,500 | 12.30 |
| 01560500 | Dunning Creek at Yount | 40 03 | 78 28 | 191 | 1.43 | 89 | 21.70 | 27,100 | 20.27 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow: Stage (ft) | Median flow: Discharge ($ft^3/s$) | 100-year flood: Stage (ft) | 100-year flood: Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA C--Continued | | | | | | | | |
| 01561000 | Brush Creek at Gapsville | 39 57 | 78 15 | 36.8 | 2.25 | 21.0 | 11.00 | 7,330 | 8.75 |
| 01562000 | Raystown Branch Juniata River at Saxton | 40 13 | 78 16 | 756 | 1.88 | 400 | 21.71 | 59,000 | 19.83 |
| 01562500 | Great Trough Creek near Markleton | 40 21 | 78 08 | 84.6 | 1.59 | 42 | 8.45 | 8,100 | 6.86 |
| 01563500 | Juniata River at Mapleton Depot | 40 24 | 77 56 | 2,030 | 3.39 | 1,200 | 34.06 | 126,600 | 30.67 |
| 01563800 | Elders Branch near Hustontown | 40 05 | 78 03 | 3.46 | 3.96 | 1.05 | 9.85 | 829 | 5.89 |
| 01564500 | Aughwick Creek near Three Springs | 40 13 | 77 55 | 205 | 3.26 | 90 | 19.80 | 26,900 | 16.54 |
| 01565920 | Lick Run near East Waterford | 40 21 | 77 39 | 8.38 | 2.70 | 4.2 | 10.40 | 2,720 | 7.70 |
| 01566000 | Tuscarora Creek near Port Royal | 40 31 | 77 25 | 214 | 3.62 | 110 | 21.15 | 22,300 | 17.53 |
| 01567500 | Bixler Run near Loysville | 40 22 | 77 24 | 15.0 | 2.91 | 7.5 | 10.40 | 8,820 | 7.49 |
| 01568000 | Sherman Creek at Shermans Dale | 40 19 | 77 10 | 200 | 1.48 | 130 | 20.40 | 34,500 | 18.92 |
| 01569000 | Stony Creek near Dauphin | 40 23 | 76 55 | 33.2 | 1.57 | 38 | 11.87 | 6,310 | 10.30 |
| 01569340 | Newburg Run at Newburg | 40 08 | 77 33 | 5.28 | 1.65 | 3.7 | 6.91 | 3,000 | 5.26 |
| 01572000 | Lower Little Swatara Creek at Pine Grove | 40 32 | 76 23 | 34.3 | 1.31 | 30 | 10.50 | 4,260 | 9.19 |
| 01572900 | Reeds Creek near Ono | 40 24 | 76 33 | 8.63 | 1.42 | 5.4 | 9.90 | 3,780 | 8.48 |
| 01573000 | Swatara Creek at Harper Tavern, | 40 24 | 76 35 | 337 | 1.99 | 310 | 21.50 | 43,300 | 19.51 |
| 01573500 | Manada Creek at Manada Gap | 40 24 | 76 43 | 13.5 | 1.70 | 14 | 11.00 | 4,190 | 9.30 |
| 01574000 | West Conewago Creek near Manchester | 40 05 | 76 43 | 510 | 3.17 | 230 | 21.16 | 56,900 | 17.99 |
| 01574500 | Codorus Creek at Spring Grove | 39 53 | 76 51 | 75.5 | 2.20 | 43 | 14.00 | 14,500 | 11.80 |
| 01575000 | South Branch Codorus Creek near York | 39 55 | 76 45 | 117 | 1.18 | 68 | 20.30 | 23,000 | 19.12 |
| 01575500 | Codorus Creek near York | 39 57 | 76 45 | 222 | 2.32 | 120 | 23.00 | 25,700 | 20.68 |
| 01576320 | Stony Run at Reamstown | 40 13 | 76 08 | 3.55 | .60 | 2.6 | 9.20 | 1,720 | 8.60 |
| 01576500 | Conestoga River at Lancaster | 40 03 | 76 17 | 324 | 3.50 | 240 | 20.78 | 36,900 | 17.28 |
| 01577500 | Muddy Creek at Castle Fin | 39 46 | 76 19 | 133 | 3.57 | 120 | 22.80 | 22,000 | 19.23 |
| 01577940 | Broad Creek tributary at Whiteford, MD | 39 42 | 76 22 | .77 | .01 | .58 | 3.00 | 378 | 2.99 |
| 01578200 | Conowingo Creek near Buck | 39 51 | 76 12 | 8.71 | 2.41 | 6.6 | 11.50 | 3,850 | 9.09 |
| 01578400 | Bowery Run near Quarryville | 39 54 | 76 07 | 5.98 | 2.51 | 4.5 | 9.90 | 5,870 | 7.39 |
| 01600700 | Little Wills Creek at Bard | 39 56 | 78 40 | 10.2 | 5.80 | 3.1 | 11.00 | 3,000 | 5.20 |
| 01601000 | Wills Creek below Hyndman | 39 49 | 78 43 | 146 | 2.30 | 60 | 13.10 | 15,700 | 10.80 |
| 01613050 | Tonoloway Creek near Needmore | 39 54 | 78 08 | 10.7 | 3.06 | 4.5 | 11.60 | 1,990 | 8.54 |
| 01619000 | Antietam Creek near Waynesboro | 39 43 | 77 36 | 93.5 | 3.30 | 88 | 15.10 | 8,270 | 11.80 |
| 03007800 | Allegheny River at Port Allegany | 41 48 | 78 18 | 248 | 2.97 | 275 | 23.00 | 24,200 | 20.03 |
| 03008000 | Newell Creek near Port Allegany | 41 54 | 78 21 | 7.79 | 2.55 | 5.5 | 6.60 | 3,920 | 4.05 |
| 03009680 | Potato Creek at Smethport | 41 49 | 78 26 | 160 | 2.92 | 190 | 17.15 | 16,800 | 14.23 |
| 03010500 | Allegheny River at Eldred | 41 58 | 78 23 | 550 | 3.80 | 450 | 26.50 | 45,000 | 22.70 |
| 03010655 | Oswayo Creek at Shinglehouse | 41 57 | 78 12 | 98.7 | 4.21 | 96 | 19.00 | 11,500 | 14.79 |
| 03023000 | Cussewago Creek near Meadville | 41 40 | 80 13 | 90.2 | 2.45 | 45 | 15.55 | 4,800 | 13.10 |
| 03028000 | West Branch Clarion River at Wilcox | 41 35 | 78 42 | 63.0 | 1.83 | 64 | 12.65 | 8,420 | 10.82 |
| 03029000 | Clarion River at Ridgway | 41 25 | 78 44 | 303 | 2.93 | 310 | 22.20 | 30,100 | 19.27 |
| 03029200 | Clear Creek near Sigel | 41 19 | 79 05 | 8.67 | 2.91 | 5.4 | 8.95 | 1,400 | 6.04 |
| 03029500 | Clarion River at Cooksburg | 41 20 | 79 13 | 807 | 3.10 | 800 | 18.60 | 52,100 | 15.50 |
| 03031780 | Mill Creek near Brockway | 41 15 | 78 50 | 2.12 | 1.90 | 1.6 | 8.20 | 496 | 6.30 |
| 03031950 | Big Run near Sprankle Mills | 40 60 | 79 05 | 7.38 | 2.04 | 5.4 | 6.94 | 1,430 | 4.90 |
| 03032500 | Redbank Creek at St. Charles | 40 60 | 79 24 | 528 | 3.75 | 400 | 19.00 | 39,900 | 15.25 |
| 03034000 | Mahoning Creek at Punxsutawney | 40 56 | 79 01 | 158 | 1.82 | 135 | 18.30 | 16,400 | 16.48 |
| 03034500 | Little Mahoning Creek at McCormick | 40 50 | 79 07 | 87.4 | 2.00 | 68 | 14.60 | 8,050 | 12.60 |
| 03035000 | Mahoning Creek near Dayton | 40 54 | 79 14 | 321 | 2.65 | 260 | 14.00 | 21,100 | 11.35 |
| 03038000 | Crooked Creek at Idaho | 40 39 | 79 21 | 191 | 2.83 | 120 | 17.30 | 16,500 | 14.47 |
| 03039000 | Crooked Creek at Crooked Creek Dam | 40 43 | 79 31 | 278 | 1.45 | 160 | 19.50 | 22,000 | 18.05 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow: Stage (ft) | Median flow: Discharge ($ft^3/s$) | 100-year flood: Stage (ft) | 100-year flood: Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA C--Continued | | | | | | | | |
| 03039200 | Clear Run near Buckstown | 40 03 | 78 50 | 3.68 | 2.46 | 3.3 | 6.90 | 683 | 4.44 |
| 03040000 | Stonycreek River at Ferndale | 40 17 | 78 55 | 451 | 3.06 | 310 | 18.08 | 44,300 | 15.02 |
| 03041000 | Little Conemaugh River at East Conemaugh | 40 21 | 78 53 | 183 | 1.14 | 136 | 12.20 | 23,200 | 11.06 |
| 03041500 | Conemaugh River at Seward | 40 25 | 79 02 | 715 | 2.79 | 660 | 22.27 | 70,600 | 19.48 |
| 03042000 | Blacklick Creek at Josephine | 40 28 | 79 11 | 192 | 3.69 | 170 | 14.20 | 25,600 | 10.51 |
| 03042170 | Stoney Run at Indiana | 40 37 | 79 10 | 4.39 | 2.20 | 3.35 | 11.20 | 852 | 9.00 |
| 03042200 | Little Yellow Creek near Strongstown | 40 34 | 78 57 | 7.36 | 3.11 | 5.5 | 7.80 | 2,360 | 4.69 |
| 03042500 | Two Lick Creek at Graceton | 40 31 | 79 10 | 171 | 2.34 | 130 | 15.88 | 23,100 | 13.54 |
| 03043000 | Blacklick Creek at Blacklick | 40 28 | 79 12 | 390 | 3.80 | 340 | 14.60 | 38,300 | 10.80 |
| 03045000 | Loyalhanna Creek at Kingston | 40 18 | 79 20 | 172 | 2.60 | 150 | 13.80 | 21,700 | 11.20 |
| 03045500 | Loyalhanna Creek at New Alexandria | 40 24 | 79 26 | 265 | 3.10 | 210 | 19.10 | 26,400 | 16.00 |
| 03047500 | Kiskiminetas River at Avonmore | 40 32 | 79 28 | 1,723 | 4.30 | 1,600 | 38.50 | 127,500 | 34.20 |
| 03049000 | Buffalo Creek near Freeport | 40 23 | 79 42 | 137 | 1.47 | 77 | 13.05 | 13,000 | 11.58 |
| 03049800 | Little Pine Creek near Etna | 40 31 | 79 56 | 5.78 | .46 | 2.7 | 5.20 | 1,630 | 4.74 |
| 03070500 | Big Sandy Creek at Rockville, WV | 39 37 | 79 42 | 200 | 4.90 | 212 | 18.40 | 23,500 | 13.50 |
| 03071000 | Cheat River near Pisgah, WV | 39 36 | 79 47 | 1,354 | 5.50 | 1,740 | 28.70 | 114,000 | 23.20 |
| 03072000 | Dunkard Creek at Shanopin | 39 46 | 79 58 | 229 | 1.82 | 81 | 14.80 | 19,400 | 12.98 |
| 03072590 | Georges Creek at Smithfield | 39 48 | 79 48 | 16.3 | 2.38 | 8.4 | 12.80 | 2,390 | 10.42 |
| 03072840 | Tenmile Creek near Clarksville | 40 00 | 80 03 | 133 | 1.37 | 75 | 8.90 | 17,900 | 7.53 |
| 03072880 | Browns Creek near Nineveh | 39 56 | 80 17 | 17.5 | 3.14 | 6.8 | 12.40 | 3,860 | 9.26 |
| 03073000 | South Fork Tenmile Creek at Jefferson | 39 55 | 80 04 | 180 | 1.52 | 58 | 19.00 | 14,500 | 17.48 |
| 03074300 | Lick Run near Hopwood | 39 52 | 79 42 | 3.80 | 1.56 | 3.3 | 4.70 | 824 | 3.14 |
| 03074500 | Redstone Creek at Waltersburg | 39 59 | 79 46 | 73.7 | .62 | 52 | 13.09 | 6,950 | 12.47 |
| 03078000 | Casselman River at Grantsville, MD | 39 42 | 79 08 | 62.5 | 1.65 | 64 | 9.70 | 7,060 | 8.05 |
| 03078500 | Big Piney Run near Salisbury | 39 44 | 79 03 | 24.5 | 2.10 | 15 | 7.90 | 5,570 | 5.80 |
| 03079000 | Casselman River at Markleton | 39 52 | 79 14 | 382 | 1.86 | 310 | 12.80 | 34,900 | 10.94 |
| 03080000 | Laurel Hill Creek at Ursina | 39 49 | 79 19 | 121 | 1.40 | 140 | 11.00 | 11,500 | 9.60 |
| 03081000 | Youghiogheny River below Confluence | 39 50 | 79 22 | 1,029 | 2.57 | 1,200 | 18.60 | 58,800 | 16.03 |
| 03082200 | Poplar Run near Normalville | 40 01 | 79 26 | 9.27 | 2.40 | 9.1 | 8.35 | 1,880 | 5.95 |
| 03082500 | Youghiogheny River at Connellsville | 40 01 | 79 36 | 1,326 | 2.92 | 1,500 | 18.60 | 73,000 | 16.68 |
| 03083000 | Green Lick Run at Green Lick Reservoir | 40 06 | 79 30 | 3.07 | .57 | 2.5 | 3.35 | 1,250 | 2.78 |
| 03083600 | Gillespie Run near Sutersville | 40 14 | 79 43 | 4.04 | .67 | 2.1 | 7.90 | 1,130 | 7.23 |
| 03084000 | Abers Creek near Murrysville | 40 27 | 79 43 | 4.39 | 1.62 | 2.2 | 7.90 | 1,520 | 6.28 |
| 03084500 | Turtle Creek at Trafford | 40 23 | 79 46 | 55.9 | 1.15 | 33 | 11.70 | 7,000 | 10.55 |
| 03085500 | Chartiers Creek at Carnegie | 40 24 | 80 06 | 257 | 1.40 | 152 | 14.90 | 16,500 | 13.50 |
| 03086100 | Big Sewickley Creek near Ambridge | 40 36 | 80 10 | 15.6 | 3.30 | 7.6 | 10.10 | 2,610 | 6.80 |
| 03100000 | Shenango River near Turnersville | 41 31 | 80 28 | 152 | 5.80 | 78 | 16.50 | 10,600 | 10.70 |
| 03101000 | Sugar Run at Pymatuning Dam | 41 30 | 80 28 | 9.34 | .44 | 2.6 | 6.53 | 2,530 | 6.09 |
| 03102500 | Little Shenango River at Greenville | 41 25 | 80 23 | 104 | 1.57 | 59 | 14.20 | 8,550 | 12.63 |
| 03103000 | Pymatuning Creek near Orangeville | 41 19 | 80 29 | 169 | 2.35 | 63 | 12.50 | 9,620 | 10.15 |
| 03104000 | Shenango River at Sharon | 41 14 | 80 31 | 608 | 3.00 | 300 | 20.40 | 30,400 | 17.40 |
| 03104500 | Shenango River at New Castle | 41 00 | 80 21 | 792 | 2.14 | 380 | 16.50 | 31,100 | 14.36 |
| 03106000 | Connoquenessing Creek near Zelienople | 40 49 | 80 15 | 356 | 1.82 | 190 | 16.10 | 20,860 | 14.28 |
| 03108000 | Raccoon Creek at Moffatts Mill | 40 38 | 80 20 | 178 | 1.86 | 84 | 12.50 | 13,400 | 10.64 |
| 03111150 | Brush Run near Buffalo | 40 12 | 80 24 | 10.3 | 2.23 | 3.7 | 9.90 | 2,260 | 7.67 |
| 04213040 | Raccoon Creek near West Springfield | 41 57 | 80 27 | 2.53 | 1.67 | 1.3 | 8.70 | 602 | 7.03 |
| 04213200 | Mill Creek at Erie | 42 06 | 80 05 | 9.16 | 8.67 | 5.6 | 13.70 | 1,930 | 5.03 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow Stage (ft) | Median flow Discharge ($ft^3/s$) | 100-year flood Stage (ft) | 100-year flood Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA D | | | | | | | | |
| 01542810 | Waldy Run near Emporium | 41 35 | 78 18 | 5.24 | 3.47 | 2.7 | 6.80 | 945 | 3.33 |
| 03011800 | Kinzua Creek near Guffey | 41 56 | 78 43 | 46.4 | 2.45 | 45 | 9.15 | 6,360 | 6.70 |
| 03012500 | Allegheny River near Kinzua | 41 51 | 79 00 | 2,179 | 8.40 | 2,100 | 20.20 | 65,500 | 11.80 |
| 03015000 | Conewango Creek at Russell | 41 56 | 79 08 | 816 | 3.38 | 880 | 13.00 | 24,300 | 9.62 |
| 03015080 | Akeley Run near Russell | 41 56 | 79 06 | 9.64 | .43 | 9.5 | 4.70 | 1,150 | 4.27 |
| 03015280 | Jackson Run near North Warren | 41 54 | 79 14 | 12.8 | 1.98 | 11.8 | 5.55 | 1,110 | 3.57 |
| 03015390 | Hare Creek near Corry | 41 56 | 79 39 | 12.3 | 3.40 | 11.5 | 7.05 | 2,300 | 3.65 |
| 03015500 | Brokenstraw Creek at Youngsville | 41 51 | 79 19 | 321 | 2.40 | 280 | 13.50 | 17,000 | 11.10 |
| 03017500 | Tionesta Creek at Lynch | 41 36 | 79 03 | 233 | 1.60 | 235 | 11.35 | 15,600 | 9.75 |
| 03017800 | Minister Creek near Truemans | 41 37 | 79 09 | 10.8 | .65 | 9.5 | 5.20 | 1,150 | 4.55 |
| 03019000 | Tionesta Creek at Nebraska | 41 28 | 79 23 | 469 | 1.38 | 390 | 10.68 | 20,000 | 9.30 |
| 03020440 | West Branch Caldwell Creek near Grand Valley | 41 46 | 79 34 | 4.37 | 5.82 | 4.0 | 9.40 | 640 | 3.58 |
| 03020500 | Oil Creek at Rouseville | 41 29 | 79 42 | 300 | 2.45 | 260 | 11.60 | 19,100 | 9.15 |
| 03021350 | French Creek at Wattsburg | 42 01 | 79 47 | 92.0 | 3.97 | 110 | 13.75 | 9,240 | 9.78 |
| 03021410 | West Branch French Creek near Lowville | 42 05 | 79 51 | 52.3 | 3.90 | 60 | 11.10 | 6,370 | 7.20 |
| 03021500 | French Creek at Carters Corners | 41 57 | 79 53 | 208 | 2.93 | 180 | 13.20 | 20,000 | 10.27 |
| 03021700 | Little Conneautee Creek near McKean | 41 56 | 80 05 | 3.60 | 1.35 | 2.2 | 4.82 | 893 | 3.47 |
| 03022500 | French Creek at Saegerstown | 41 43 | 80 09 | 629 | 3.25 | 510 | 17.75 | 26,000 | 14.50 |
| 03022540 | Woodcock Creek at Blooming Valley | 41 41 | 80 03 | 31.1 | 5.96 | 29.4 | 11.60 | 3,080 | 5.64 |
| 03023500 | French Creek at Carlton | 41 28 | 80 01 | 998 | 1.72 | 830 | 15.15 | 31,700 | 13.43 |
| 03024000 | French Creek at Utica | 41 26 | 79 57 | 1,028 | 3.00 | 920 | 15.35 | 32,000 | 12.35 |
| 03025000 | Sugar Creek at Sugarcreek | 41 26 | 79 53 | 166 | 2.82 | 135 | 12.50 | 11,400 | 9.68 |
| 03025200 | Patchel Run near Franklin | 42 15 | 79 51 | 5.69 | 3.04 | 5.2 | 5.88 | 1,140 | 2.84 |
| 03026500 | Sevenmile Run near Rasselas | 41 38 | 78 35 | 7.84 | 2.04 | 7.0 | 5.73 | 3,250 | 3.69 |
| 03029400 | Toms Run at Cooksburg | 41 20 | 79 13 | 12.6 | 1.38 | 7.9 | 5.50 | 1,140 | 4.12 |
| 03104760 | Harthegig Run near Greenfield | 41 11 | 80 20 | 2.26 | 1.17 | .82 | 4.00 | 560 | 2.83 |
| 03106500 | Slippery Rock Creek at Wurtemburg | 40 53 | 80 14 | 398 | 1.28 | 250 | 13.30 | 21,300 | 12.02 |

Table 2.--Summary of gaging-station data--Continued

[°, degrees; ', minutes; $mi^2$, square miles; ft, feet; $ft^3/s$, cubic feet per second]

| Station number | Station name | Latitude (°,') | Longitude (°,') | Drainage area ($mi^2$) | Median flow Stage (ft) | Median flow Discharge ($ft^3/s$) | 100-year flood Stage (ft) | 100-year flood Discharge ($ft^3/s$) | Depth of 100-year flood above median stage (ft) |
|---|---|---|---|---|---|---|---|---|---|
| | AREA E | | | | | | | | |
| 01451500 | Little Lehigh Creek near Allentown | 40 35 | 75 29 | 80.8 | 2.26 | 55.0 | 13.30 | 14,000 | 11.04 |
| 01452000 | Jordan Creek at Allentown | 40 37 | 75 29 | 75.8 | 2.87 | 58 | 10.53 | 13,300 | 7.66 |
| 01452300 | East Branch Monocacy Creek near Bath | 40 43 | 75 22 | 5.35 | 1.96 | .85 | 7.25 | 1,490 | 5.29 |
| 01452500 | Monocacy Creek at Bethlehem | 40 38 | 75 22 | 44.5 | 2.34 | 36 | 10.17 | 5,660 | 7.83 |
| 01454600 | Polk Valley Run at Hellertown | 40 34 | 75 20 | 2.14 | 1.65 | .35 | 5.40 | 857 | 3.75 |
| 01470720 | Maiden Creek trib. at Lenhartsville | 40 34 | 75 53 | 7.46 | 2.36 | 4.8 | 7.72 | 2,550 | 5.36 |
| 01470756 | Maiden Creek at Virginville | 40 31 | 75 53 | 159 | 2.48 | 153 | 18.40 | 15,500 | 15.92 |
| 01470779 | Tulpehocken Creek near Bernville | 40 25 | 76 10 | 66.5 | 2.08 | 79 | 13.15 | 9,300 | 11.07 |
| 01470960 | Tulpehocken Creek at Blue Marsh Dam near Reading | 40 22 | 76 01 | 175 | 2.71 | 150 | 13.87 | 17,800 | 11.16 |
| 01472174 | Pickering Creek near Chester Springs | 40 05 | 75 38 | 5.98 | 2.46 | 6.1 | 5.61 | 4,720 | 3.15 |
| 01480300 | West Branch Brandywine Creek near Honey Brook | 40 04 | 75 52 | 18.7 | 1.35 | 12 | 11.50 | 8,480 | 10.15 |
| 01480500 | West Branch Brandywine Creek at Coatesville | 39 59 | 75 50 | 45.8 | 3.98 | 46 | 11.90 | 13,630 | 7.92 |
| 01480675 | Marsh Creek near Glenmoore | 40 06 | 75 45 | 8.57 | 1.62 | 7.9 | 7.10 | 2,020 | 5.48 |
| 01480680 | Marsh Creek near Lyndell | 40 04 | 75 44 | 17.8 | 2.23 | 13 | 9.30 | 3,240 | 7.07 |
| 01480800 | East Branch Brandywine Creek at Downingtown | 40 00 | 75 42 | 81.6 | .50 | 56 | 11.40 | 9,690 | 10.90 |
| 01546500 | Spring Creek near Axemann | 40 53 | 77 48 | 87.2 | 2.43 | 61 | 7.03 | 4,460 | 4.60 |
| 01547100 | Spring Creek at Milesburg | 41 56 | 77 47 | 142 | 2.64 | 150 | 13.60 | 8,790 | 10.96 |
| 01547200 | Bald Eagle Creek below Spring Creek at Milesburg | 40 57 | 77 47 | 265 | .89 | 220 | 10.93 | 15,300 | 10.04 |
| 01547700 | Marsh Creek at Blanchard | 41 04 | 77 36 | 44.1 | 2.54 | 21 | 7.39 | 5,730 | 4.85 |
| 01548000 | Bald Eagle Creek at Beech Creek Station | 41 04 | 77 34 | 559 | 2.21 | 430 | 15.51 | 28,650 | 13.30 |
| 01553050 | White Deer Hole Creek near Elimsport | 41 07 | 77 04 | 18.2 | 4.84 | 22 | 11.83 | 4,200 | 6.99 |
| 01553130 | Sand Spring Run near White Deer | 41 04 | 77 05 | 4.93 | 3.01 | 6.4 | 5.75 | 1,630 | 2.74 |
| 01565000 | Kishacoquillas Creek at Reedsville | 40 39 | 77 35 | 164 | 2.53 | 110 | 15.00 | 13,200 | 12.47 |
| 01565700 | Little Lost Creek near Oakland Mills | 40 36 | 77 19 | 6.52 | 4.47 | 2.9 | 8.80 | 1,630 | 4.33 |
| 01566500 | Cocolamus Creek near Millerstown | 40 34 | 77 07 | 57.2 | 2.17 | 34 | 9.82 | 7,520 | 7.65 |
| 01570000 | Conodoguinet Creek near Hogestown | 40 15 | 77 01 | 470 | 1.80 | 350 | 14.83 | 24,700 | 13.03 |
| 01571500 | Yellow Breeches Creek near Camp Hill | 40 13 | 76 54 | 216 | 1.35 | 200 | 16.20 | 13,700 | 14.85 |
| 01573086 | Beck Creek near Cleona | 40 19 | 76 29 | 7.87 | 3.61 | 5.2 | 10.20 | 3,280 | 6.59 |
| 01603500 | Evitts Creek near Centerville | 39 47 | 78 39 | 30.2 | 1.44 | 14 | 6.55 | 4,890 | 5.11 |

[1] Additional information on the locations and records of active gaging stations is given in Water Resources Data for Pennsylvania (U.S. Geological Survey, 1984).

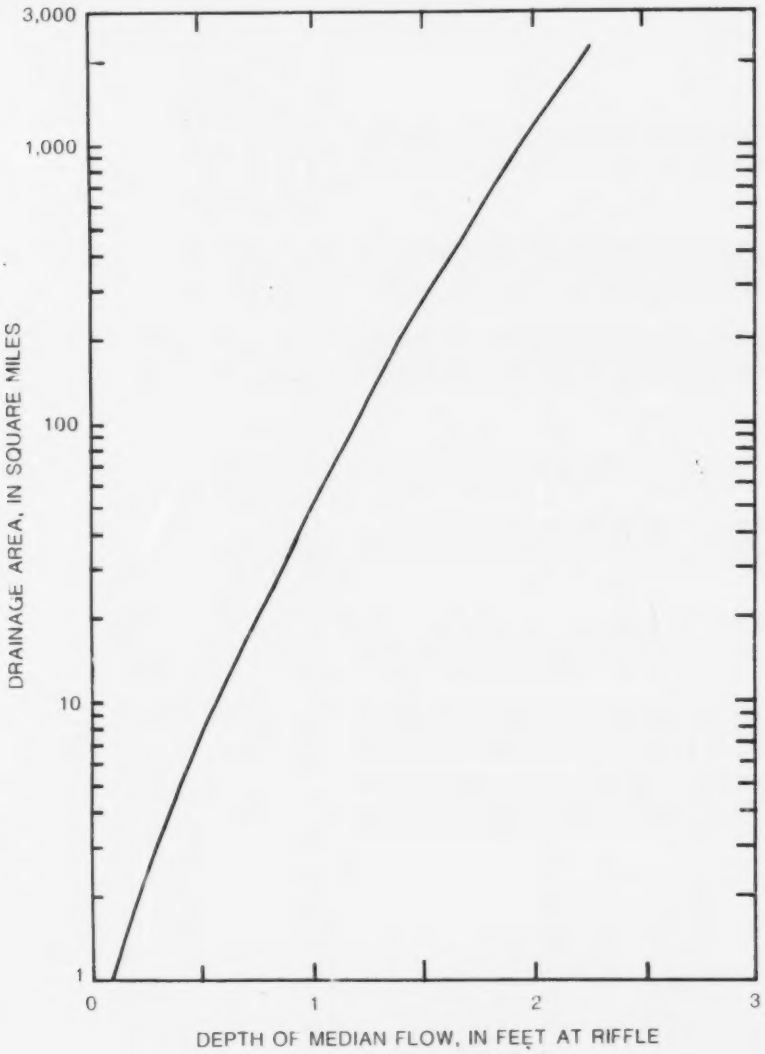


Figure 2.--Relation between drainage area and median depth of flow on riffle.

## Application of Results

Determinations of total flood depth are required if flood-inundation maps are to be prepared or if profiles are to be plotted to show flood depth over the streambed. The procedure for estimating the depth of the 100-year flood above median stage, at a given site on a stream, is as follows:

1. Determine the drainage area, in square miles, of the basin above the site of interest.

2. Determine the hydrologic area for the site from plate 1.

3. Compute the 100-year flood depth ($D_{100}$) from the appropriate areal equation (table 1) or, alternatively, from the appropriate graph in figure 1.

In order to determine the total 100-year depth at the site of interest, it is necessary to add the depth at median stage to the $D_{100}$ depth, as determined by the above procedure. The depth at median stage can be estimated from figure 2, which is of statewide applicability.

Elevations of the 100-year flood at, or in the vicinity of, the site of interest can be determined by adding the total 100-year depth to the elevation of the streambed at its lowest point on natural riffles. Elevations for such riffle points are best determined by spirit- or electronic-level surveys. High-quality contour maps with contour intervals of 2 feet or less can provide adequate elevation control for flood profiling or mapping of most small, steep-gradient streams.

Flood profiles and maps of lesser accuracy can be developed from 7-1/2 minute U.S. Geological Survey topographic maps, which are available for all of Pennsylvania at contour intervals of 10 or 20 feet. It is commonly assumed that elevations of median stages coincide with the elevations of contour lines where they cross a stream. Thus, depths ($D_{100}$) estimated from figure 1 can be added to contour elevations to estimate 100-year-flood elevations at the points of contour crossings. Elevations for flood profiles that are developed in this manner can be no more accurate than the topographic map used. Third-order leveling at several localities in Pennsylvania has shown that position errors for these contour lines commonly exceed a quarter of a contour interval, and some may exceed half of a contour interval.

## Accuracy and Limitations

The accuracy of each flood-depth equation (table 1) was measured by comparing the 100-year depth computed through use of the equation with observed depths (table 2) at gaged sites in the delineated (pl. 1) hydrologic areas. Standard errors of estimate for the five equations range from 16 to 28 percent, as shown in table 1.' Two out of three depth ($D_{100}$) estimates can be expected to be in error by no more than the standard error of the equation used.

The depth equations should be applied only for drainage areas that fall within the size ranges shown in table 1. Each applicable range closely matches the range of drainage-area values used in the respective regression. The upper limits of the applicable ranges for areas A and E (325 and 560 $mi^2$, respectively) approximate those of the largest unregulated streams in these two areas. Most streams that drain more than 2,200 $mi^2$--the upper limit of the applicable ranges for areas B, C, and D--are regulated.

Depth estimates for sites whose basins lie in more than one of the delineated hydrologic areas (pl. 1) can be proportioned according to the fraction of basin within each area.

The depth equations should not be applied for streams that have been channeled or are highly regulated. The equations should not be used for streams that drain urbanized areas or for those that have more than 15 percent of their drainage controlled by reservoirs, ponds, or swamps. This suggested limit on the percentage of controlled area is based on studies by Aron and

Kibler (1981, fig. 5-3). Their studies show the reduction in 100-year discharge resulting from 15 percent of controlled area is usually in the range of 5 to 13 percent. The corresponding range in percent of reduction in flood depths will be somewhat less. The relationship for area A incorporates the moderating effects of ponds and swamps on 100-year flood depths in streams that drain the small watersheds that are typical of the Pocono Mountain area.

A constriction or a hydraulic structure, such as a bridge, culvert, or dam, will usually cause a backwater condition on the upstream side of the constriction or structure. The 100-year depth in the reach of backwater will usually exceed that predicted through use of figure 2 and the areal equation of table 1.

The standard error of the median-depth relation (fig. 2) is 0.25 ft. About two-thirds of median-depth estimates made through use of this figure will be in error by less than that amount; however, about 90 percent of measured median depths for drainage areas of less than 10 $mi^2$ are within 0.25 ft of the depths indicated by figure 2. For drainage areas greater than 10 $mi^2$, about 96 percent of median-depth estimates will be in error by less than two standard errors of estimate, or 0.50 ft. Median-depth relations for the five individual hydrologic areas (pl. 1) showed no significant deviation from figure 2, which is based on all available riffle-depth data for the group of gaging stations (table 2).

## SUMMARY

Estimates of 100-year flood depth on the riffles in a natural, unregulated Pennsylvania stream can be made by using two relations presented in this report.

Standard errors of estimate for the relations between 100-year depths above median stage and drainage area range from 16 to 28 percent for the five delineated hydrologic areas. An additional error of less than 0.25 ft is typical for estimates of the median-depth component of 100-year depths on riffles.

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U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS REPORT
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PLATE 1

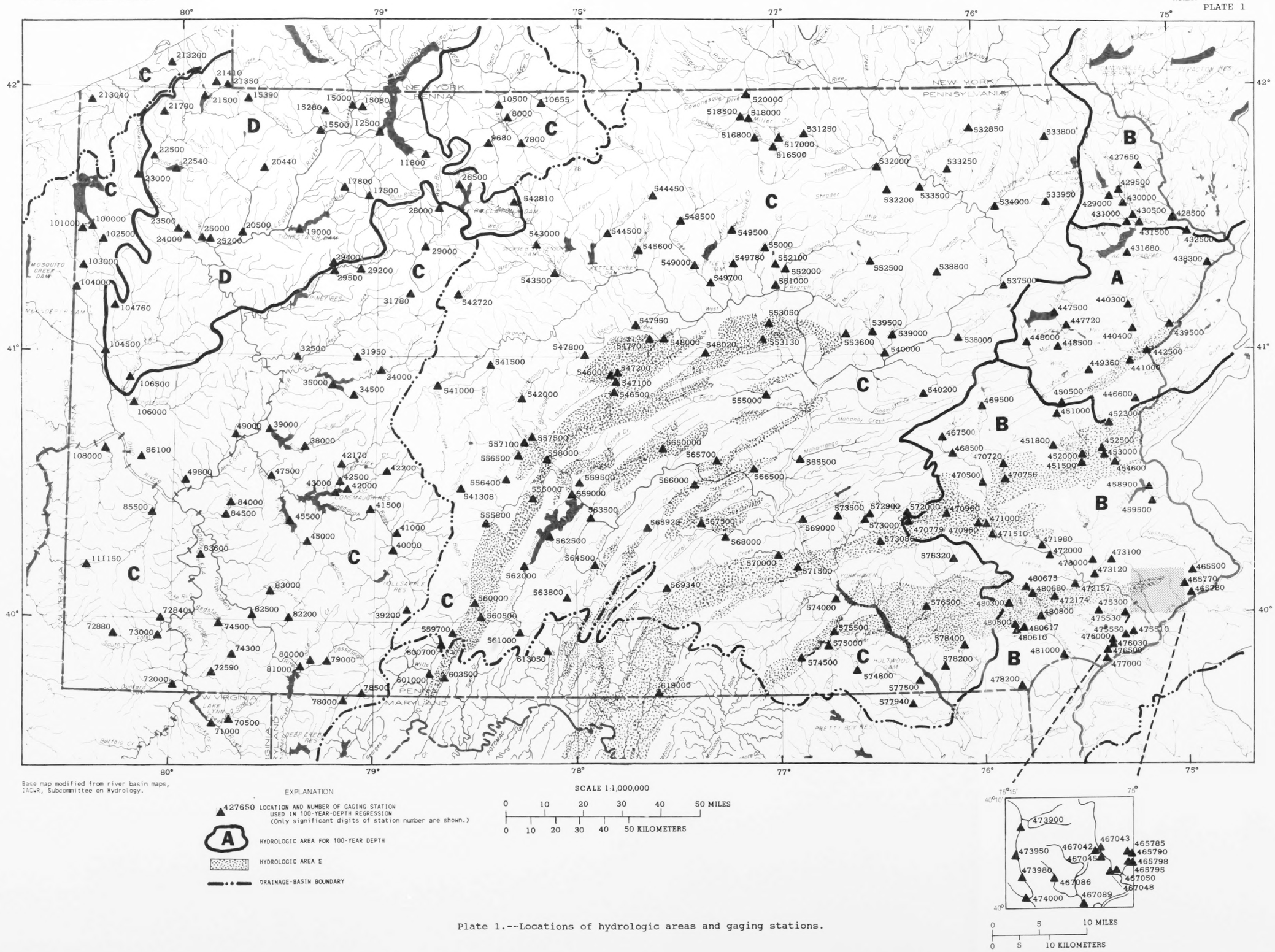


Plate 1.--Locations of hydrologic areas and gaging stations.

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